CONNECTING SENSOR NETWORKS IN SMART HOMES (GBRG)

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Abstract

The paper deals about Linux based Residential gateway built in grid environments-Grid Based Residential Gateway (GBRG). The Residential Gateways are intelligent network interface devices located at the consumer premises that allow residents to access Internet services delivered to the home while also accessing the different services offered by various smart devices located within home .This entails connecting devices to each other within the connected home and also connecting networked devices to other networks and services, thus converting into 'smart homes' and applying the same to global computing. However, such devices often have limited resources in terms of CPU, storage, battery power and communication bandwidth. Thus, there is a need to transfer ubiquitous computing application services to more powerful computational resources. Hence, the need to converge the idle processor's power from home appliances and use this to do multitude of computations required, via. the Linux based residential gateway. The paper broaches upon the proposed residential gateway and its interfacing in a grid computing environment with a brief survey on both of these technologies utilized in smart homes. The question arises on how to access on the real-time data collection from all the home appliances and how the sharing of resources takes place .This is done with the help of Sensor Networks connected in the home devices.

Keywords: Grid Computing, Smart Homes, Residential Gateway, Home Automation, Embedded networking, Sensor Networking.

I. INTRODUCTION

The convergence of consumer electronics, broadband technologies, digital entertainment and mobile communications have turned the "home automation" into “smart home”, in a way that couldn't have been predicted even a decade ago. The embedded distributed computing or the Grid computing deals with aggregating the computational power (unused CPU cycles) of all the processors that remain idle [3]. This resource can be used to support ambient intelligence processing in residential areas, as well as exported to external users as commodity, by creating Virtual dynamic organizations through secure, coordinated resource-sharing of desktop PC's, wireless devices, embedded processors among various individuals, institutions, and “smart homes/offices”.

The project deals with design and implementation of architecturally independent, reliable, cost effective Linux based residential gateway in a grid infrastructure which provides a secure and flexible controlling, monitoring and accessing of various appliances in “smart homes”.

II. THE GRID COMPUTING – PAST, PRESENT AND THE FUTURE

The Grid is an integrated infrastructure that can play the dual roles of a coordinated resource consumer as well as a donator in distributed computing environments. In a mobile grid environment, the Grid acts as a resource hungry consumer whereas in a ubiquitous computing Environment, it has the inherent potential to provide services to applications [1]. The enormous growth in the use of mobile and embedded devices in ubiquitous computing environment and their interaction with human beings, produces a huge amount of data that need to be processed efficiently anytime anywhere. However, such devices often have limited resources in terms of CPU, storage, battery power and communication bandwidth. Thus, there is a need to transfer ubiquitous computing application services to more powerful computational resources.

Hence, the need to converge the idle processor's power from home appliances and use this to do multitude of computations required, via. Linux based residential gateway. Traditionally, there have been three categories of "distributed" computing:

Cluster computing:

The servers of similar power and configuration are joined to form a virtual machine. Linux clusters are examples. Peer-to-peer: Many desktop computers are linked to aggregate processing power. The distinguishing characteristic is the machine itself, which almost exclusively is a low-power client PC. The link is via the Internet.

Distributed computing:

Increasingly known as grid computing, this approach connects a wide variety of computer types and computing resources, such as storage area networks, to create vast

"virtual" reservoirs of computers serving geographically widely separated users. The Internet or dedicated networks can be used to interconnect a wide variety of distributed computational resources (such as supercomputers, computer clusters, storage systems, data sources) and present them as a single, unified resource. A company with slightly fewer than 2,000 desktop computers can harvest nearly 1 teraflop of computing capacity. Even better, the company can capture that power from computers it already owns that sit idle at night and work at less than full capacity during the day. Universities and research institutions have long used grid-computing technology, but recently it is also making fast inroads into the business market.

III. INTERNET GRID COMPUTING (E-GRID)

The Internet is becoming a true platform, combining the qualities of service of enterprise computing with the ability to share distributed resources across the web - applications, data, storage, servers, and everything in-between[6].

At its core, grid computing is based on an open set of standards and protocols — e.g., Open Grid Services Architecture (OGSA) — that enable communication across heterogeneous, geographically dispersed environments[1][2]. With grid computing, organizations can optimize computing and data resources, pool them for large capacity workloads, share them across networks and enable collaboration.

IV. ADVANTAGES

Many organizations already have a substantial investment in their computer hardware and infrastructure, to take advantage of Grid Computing [4] several ways:

- Grids computing are complementary to existing computing and network infrastructures.
- The infrastructure required to manage a well-built GRID is extremely low.
- Grid Computing allows you to extend the use of applications you already have. This is the reason for developing my proposal of project
- When it comes to deciding whether to spend money large-scale computing systems such as workgroup clusters and supercomputers, or to invest in a Grid based infrastructure, the benefits of Grid based computing over these solutions are evident in several areas including:

  1. Cost Savings
  2. Scalability
  3. Reliability

V. EVOLUTION OF SMART HOMES

The home automation started with home security, remote controlling of TV, sharing files at home from intranet/internet, sharing printers, home control, monitoring and led to smart homes[7]. The motivating factors that encourage people to network different classes of household appliances and computers together are,

Leverage existing investments:

Sharing hardware resources is the number one motivating factor for consumers investing in new home networking interconnection technologies.

Shared Internet access:

The second most popular motivating factor fueling the deployment of home networks is shared Internet access. Home networks, in conjunction with devices called media gateways, allow different members of a family to simultaneously use a single, fast Internet access, thus saving money.

Interconnecting subsystems:

Other motivating factors include the ability of a home networking infrastructure to interconnect different types of subsystems together. For example, home security systems are also defined as a network, but instead of interconnecting devices like printers and PCs, in-home security networks connect different types of sensors to a central controller. Integrating this type of network with an existing PC-based home network helps people expand the functionality of their security system and better manage different subsystems.

Rise of multi-PC households:

The rapid growth of multi-PC homes indicates that the number of nodes in a PC network will continue to skyrocket as home networking appliances are introduced. Also, sharing PC peripherals (such as printers and scanners) between multiple PCs provides cost savings.

Evolving in-home applications:

File sizes of typical personal computer applications are growing rapidly with each generation of standard software applications. For example, the file size of a power point demonstration with the same content has doubled over the last few years. Graphics and digital photography over e-mail are now commonplace. Also, distributing video, MP3 files, and other digital content between information appliances is gaining importance.

VI. RESIDENTIAL GATEWAY:

A network gateway or residential server is an internetworking system, a system that joins two networks

together. A network gateway can be implemented completely in software, completely in hardware, or as a combination of the two. Depending on their implementation, network gateways can operate at any level of the OSI model from application protocols to low-level signaling.

Home networking is in fact a four-part equation defined by broadband access, residential gateways, home networking technologies, and information appliances. In such a smart home environment, building of efficient residential gateway using grid computing has become a prime motive for the paper.

A residential gateway connects computers, printers, scanners from anywhere at homes, office's etc. A gateway connects devices to help users store, and protect information within a home or small business network they help to connect devices to public and private networks [5]. Having access to the network infrastructure allows users to access a broad variety of remote applications and services.

Each of the home appliances contains a sensor, through which the devices are controlled by a centralized gateway. The collection of these sensor nodes forms a sensor network which is easily deployable to provide a high degree of visibility into real-world physical processes as they happen, thus benefitting a variety of applications such as environmental monitoring, surveillance and target tracking in addition to homeland security surveillance. The next paragraph deals with the brief note on Sensor Grids[7], required for our residential applications.

The Sensor Grid enables the collection, processing, sharing, and visualization, archival and searching of large amounts of sensor data from the various appliances.[7] There are several rationales for a Sensor Grid. First, the vast amount of data collected by the sensors can be processed, analyzed, and stored using the computational and data storage resources of the grid.

Second, the sensors can be efficiently shared by different users and applications under flexible usage scenarios. Each user can access a subset of the sensors during a particular time period to run a specific application, and to collect the desired type of sensor data.

Third, as sensor devices with embedded processors become more computationally powerful, it is more efficient to offload specialized tasks such as image and signal on the sensor devices.

Finally, a sensor grid provides seamless access to a wide variety of resources in a pervasive manner. Advanced techniques in artificial intelligence, data fusion, data mining, and distributed database processing can be applied to make sense of the sensor data and generate new knowledge of the environment. The results can in turn be used to optimize the operation of the sensors, or influence the operation of actuators to change the environment. Thus, sensor grids are well suited for adaptive and pervasive computing applications.

VII. TYPES OF RESIDENTIAL GATEWAYS

Gateway devices are commonly divided into the following three functional categories[6], or any combination of these three:

Data Gateway:

Data gateways are simple routers primarily used for data throughput. They provide pass-through support for network protocols and services and typically support both wired and wireless networking. Data gateways can be used to pool multiple Internet connections and secure private networks using a firewall. Some data gateways may also provide storage, such as e-mail and voice mail storage.

Multimedia Gateway:

In addition to data gateway features, multimedia gateways provide features targeted to audio and video content delivery. Multimedia gateways are often used in

conjunction with digital entertainment devices (including TVs, stereo systems, and gaming consoles) and can provide centralized storage, acting as a home server for digital media, such as photos, videos, MP3 files, and Web site hosting. Audio and video streaming are important features in an entertainment gateway, because they enable users to subscribe to Web-based services such as Video-On-Demand (VOD) and VoIP telephony features. Multimedia gateways also typically include encoding capabilities that transcode analog audio and video signals so users can enjoy media such as cable TV on a personal computer screen.

Home Control Gateway:

A home control gateway enables home control and security service management over a network. For example, users with a home control gateway can access automated lighting, heating, and security systems from work or while on vacation. Home control gateways also allow network service providers to offer new service packages and generate new revenue streams. For example, through affiliation with local utilities, service providers can securely expose energy consumption patterns to customers and provide informed opportunities such as time-of-day usage pricing[5][6].

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VIII. METHODS OF GATEWAY CONFIGURATION

iptables:

The GUI configuration tool /usr/bin/redhat-config-securitylevel can be used to choose a preconfigured firewall (High, Medium or no firewall) or it can be used to manually configure rules based on the network services your server will offer. The init script /etc/rc.d/init.d/iptables will use rules stored in /etc/sysconfig/iptables.

ipchains:

The tool that does this is lokkit (or /usr/bin/gnome-lokkit), which uses ipchains to configure firewall options for High and Low security options. To support ipchains after install, run /usr/bin/gnome-lokkit and configure a firewall. It will configure ipchains to activate the firewall. Lokkit will generate the file /etc/sysconfig/ipchains. (Used by init script /etc/rc.d/init.d/ipchains which calls /sbin/ipchains-restore)

The default Red Hat 7.1+ Linux 2.4 kernel is compiled to support both iptables and ipchains. Kernel support for ipchains is available during a kernel configuration and compilation

```
iptables --flush   Flush all the rules in filter and nat tables
iptables --table nat --flush
iptables --delete-chain        - Delete all chains that are not
                                 in default filter and nat
table
 iptables --table nat --delete-chain
# Set up IP FORWARDing and Masquerading
iptables --table nat --append POSTROUTING
      --out-interface ppp0 -j MASQUERADE
iptables --append FORWARD --in-interface eth0 -j ACCEPT
        - Assuming one NIC to local LAN
echo 1 > /proc/sys/net/ipv4/ip_forward
        - Enables packet forwarding by kernel
```

IX. RESULTS

The following figure 1. depicts the residential network environment with a residential gateway used as a interface between access network and home network.

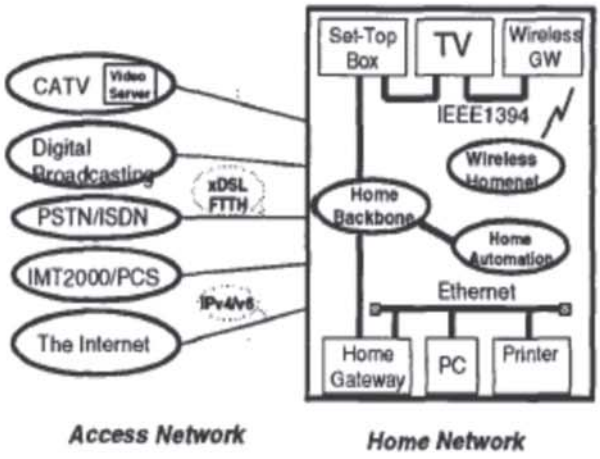

Fig. 1. Residential Network Environment

The screenshot listed out here is the List of Grid Services in figure 2. The screenshot listed out here is the application server admin console started during execution of web services as shown in figure 3.

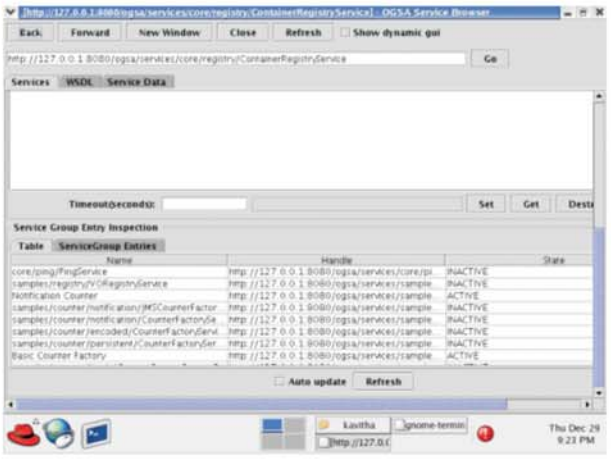

Fig. 2. List of Grid Services

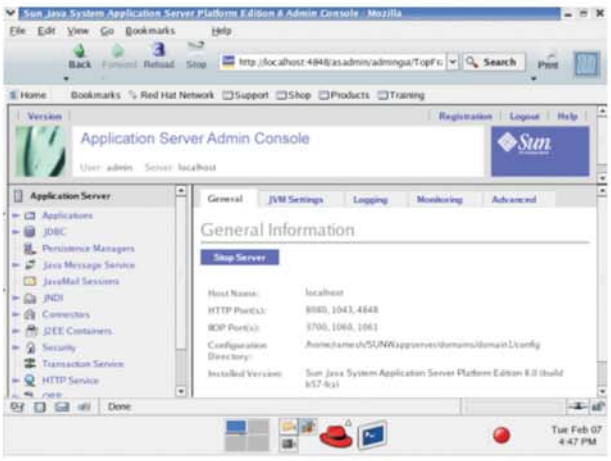

Fig. 3. Application Server Admin Console

X. CONCLUSION

Thus we have dealt on the various residential gateways and merits of smart homes .The advent of Grid computing, has enhanced to aggregate the unused power of embedded processors(sensor nodes) at home .Thus we have made a proposal to develop a Linux based residential gateway in a grid infrastructure. It is only a proposal with the results obtained and a detailed work need to be carried out in future, as the project progresses on.

The work could also be carried out for the implementation of residential gateway for global computing.

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